

Emerging Technologies in the Boiler Plant

MCCOTTER ENERGY SYSTEMS, INC



"Smart Energy. Reliable Efficiency" Reliable boiler room systems & service since 1956.



McCotter Energy Systems has focused on bringing the most reliable and efficient boiler room systems to users in Wisconsin & Upper Michigan.



BOILER ROOM EFFICIENCY TOOLS

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DECARBONIZATION MOVEMENT

- Net-Zero Greenhouse Gases by 2050
 - The Whitehouse has set a goal of 50% reduction of 2005 greenhouse gas levels by 2030.
 - Fed Government is supporting NetZero Labs in Idaho, Colorado, Pennsylvania and Washington to research power generation
- States and Municipalities are leading the way in natural gas boiler bans for new construction
 - New York City, Washington D.C., Washington State and others have passed new building codes requiring the elimination of natural gas in new construction projects
 - Some bans are scheduled to begin in 2023





Standby Systems Propane Blending Station



Oilon Heat Pump Precision **Electrode Boiler**

PROPANE/AIR BLENDING SYSTEM OVERVIEW

- Alternate Fuel Options
- About fuel gases Methane & Propane
- Propane/Air Blending Equipment Overview
- System Advantages
- Market Applications
- System Examples



Alternate Fuel Options

• Oil

- #2 Fuel Oil
- Standard of the industry

Propane Vapor

- Standby fuel for localized gas load (e.g. Boilers) when natural gas is present.
- Primary fuel in rural areas when natural gas is not present.

Electric

Limited as alternate fuel

Propane-Air

- Mixture is interchangeable with natural gas
- Primary/Standby fuel for the entire facility



METHANE AND PROPANE PROPERTIES AS A FUEL

Property	Methane	Propane
Gross Heating Value, btu/scf:	1,010	2,516
Specific Gravity:	0.554	1.523
Wobbe index, btu/scf:	1,357	2,039
Lower Flammability Limit, vol %:	5.0	2.1
Upper Flammability Limit, vol %:	15.0	10.0
Energy density as liquid, btu/gallon:	77,600	91,500



What's the Point?

• An appliance designed to burn methane does not burn propane without creating poor combustion characteristics.

 As a result, the appliance needs to be set up to burn multiple fuels. This usually includes a second gas train and in some applications changes to the burner head need to be performed.

 For dual fuel a propane/air blend offers several operation benefits and some significant cost savings.



What equipment is involved in the system?

Storage Tank & Fill Station: Propane (LPG) delivered via truck, rail and in some cases pipeline.

Pump: Typically paired with above ground tanks.

Vaporization: Liquid propane is heated to gas.

Note: If system is a propane vapor then it would be piped to appliance at his stage.

Blending: Propane vapor is precisely mixed with air to simulate natural gas.

Interconnection: Propane-air system connects to facility natural gas distribution system after the utility meter.





EQUIPMENT OVERVIEW - TANKS

• System Components

- Tanks
 - One or multiple tanks
 - Size based on the btu requirement and duration required
- Pump
 - To move propane when its gets really cold
 - Typically very little horsepower required





EQUIPMENT OVERVIEW - PUMPS

- Single or Multiple pump configurations based on application
- Typically Preassembled for ease of installation
- Pumps are not always required





EQUIPMENT OVERVIEW - VAPORIZERS











EQUIPMENT OVERVIEW - MIXERS

- Many configurations but fundamentals of design are the same.
 - Propane vapor inlet
 - Venturi's mix the propane vapor with air
 - Tank holds blended propane air mix which is then tied into the natural gas line





EQUIPMENT OVERVIEW -EXAMPLE NATURAL GAS/PROPANE-AIR CONNECTION

(NOTE - PROPANE VAPOR SYSTEMS WILL RUN DUAL GAS TRAINS TO BOILERS)





ADVANTAGES OF PROPANE/AIR BLEND

• Long term fuel storage

- Propane can be stored indefinitely. No risk of the fuel contamination or degradation.
- No need to periodically turn over fuel or dispose of old fuel.

• Little maintenance required

- No routine filter changes.
- No chemical additives needed.
- No continuously operated circulator pumps needed.

• Environmental benefits

- Cleaner combustion at the burner and lower emissions.
- No ground water contamination or risk of US EPA violations and fines.

• Lower equipment cost

 Dual Fuel equipment carries a higher initial cost. Lower equipment cost helps offset blending system cost.



ADVANTAGES OF PROPANE/AIR BLEND

• Ease of Operation

- At lose of Natural Gas, switching to Propane/Air is a simple operation. Enable system and all switching is automatic.
- System can be set up to sense loss of Natural Gas pressure and automatically switch to Propane/Air system. Often the Natural Gas equipment will not even fault.

• Ease of Installation

- Straight Propane and Oil systems require extra piping to deliver fuel to appliances
- Blended Propane/Air utilizes Natural Gas Piping for delivery.
- Natural Gas Equipment Remains Online
 - All systems firing on Natural Gas can remain operational during a loss of Natural Gas.
 - Boilers, Generators Gas Fired Air Handlers, Water Heaters, Kitchen Appliances, Laundry Equipment stay online.



System Example – Large Hospital NATURAL GAS BACKUP FOR CRITICAL INFRASTRUCTRE

System Type: Propane-Air

Replacement Capacity: 250 MMBtu/Hr

Average Heating Requirement: 125 MMBtu/Hr

Replacement Level: 100%

On-site Fuel Storage: 90,000 Gallons (52 Hour Supply)





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ELECTRIC RESISTANCE BOILERS ELECTRODE BOILERS HYBRID ELECTRIC BOILERS









ELECTRIC RESISTANCE BOILERS

- Supply Voltage 208V 600V (steam or water)
- Water 30-4,320 KW (102 -14,688 MBH) 30-415 PSI Design
- Steam 7.5-4000KW 15-2000
 PSI Design







Hot Water

Steam

Lund

ELECTRIC STEAM BOILERS

RESISTANCE VS. ELECTRODE







ELECTRODE BOILERS

- 80-4,200 BHP (2,700-140,000 PPH)
- Pressures: 100-400 PSI
- Voltage 208-480
- 99% Efficient with Zero Emissions
- Quiet Operation



How Jet Electrode Boilers generate steam.



Water Resistivity Heats Feedwater, Portion Vaporizes to Steam

> Feedwater Returns to Bottom of Vessel for Recirculation

Level Control Adds Feedwater As Needed

Boiler Control Parameter is Actual Vessel Pressure vs. Set-point





HYBIRD ELECTRIC BOILERS

- 30-2,000 BHP (1004 TO 66950 MBH
- 3 FUEL BOILER
- Voltage 208-480





HYBRID GAS, OIL, OR ELECTICITY



Electric Boilers example at \$.07/kWh:

- 1MW = 3,340 lb/hr steam @ 200 psi
- \$70 = 3,340 lb/hr steam
- = \$20.96 / (1000 lb/hr steam)



Gas Boiler example at \$3.50/mmbtu NG:

- Enthalpy of 200 psi steam: 1199
- Enthalpy of 203°F Feedwater: 171
- BTU/lb of steam: 1028
- \$/BTU x 1000 lbs. of steam x 1028 BTU/lb/eff.
- 3.50/1000000 x 1000 x 1029 / .875
- = **\$4.11** / (1000 lb/hr steam



800 HP BOILER

New construction at \$125/sq ft			
280	ft2	\$35,000.00	
144	ft2	\$18,000.00	
	Savings	\$17,000.00	







NO OPERATOR REQUIRED

\$175,00 to \$700,000 Possible Savings

ADVANCES IN HEAT PUMP PERFORMANCE AND CAPACITY







(2) RIELLO RTC 10,000 MBH GAS/#2 OIL CONDENSING WATER BOILERS



HEAT PUMP DEVELOPMENT IS PRODUCING HIGHER TEMPERATURE & CAPACITY SYSTEMS

INDUSTRIAL HEAT PUMPS AND CHILLERS 102 MBH - 10,000 MBH (800 TONS)







Heat pump basics



One degree better

HEAT PUMP WORKING PRINCIPLE

Heat pumps basics







Heat pump basics Advances in Heat Pump Technology Heat Pump Applications



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REFRIGERANTS

Industrial heat pumps and chillers 102 MBh - 10,000 MBh (800 Tons)

Refrigerant	Class	Safety	GWP value*	ODP value	Max. Outlet T
R410A	HFC	A1	1920	0	149°F
R134a	HFC	A1	1300	0	176 °F
R513A	HFC/HF O	A1	573	0	176 °F
R450A	HFC/HF O	A1	547	0	194 °F
R1234ze	HFO	A2L	<1	0	230 °F

* Value calculated by using the IPCC 5th rev calculation method HFO-Hydrofluroroofelin=0 ODP Some HFOs, which have very low global warming potential, are mildly flammable and are classified as A2L. This indicates that they are of **lower toxicity and have low burning velocity**.



RE-SCROLL-SERIES





- Up to 149 deg F hot water with full power
- Refrigerant
 - R410A

Based on scroll compressors





Pos.	Part	Pos.	Part	
1	Control cabin	5	Compressor	
2	Control panel	6	Refrigerant pressure double relief valve with change valve	
3	Evaporator	7	Dryer-Filter	
4	Condenser			



S-SCREW-SERIES

ChillHeat product family

ChillHeat S 180 - S 490 main parts

Large capacity and good part-load range

- Up to 185 deg F hot water with full capacity
- Refrigerant choices
 - R134a, R450A, R513A, R1234ze

Based on screw compressors



Variable frequency drives as option

- Higher capacity
- Precise control



Pos.	Part	Pos.	Part
1	Control panel	6	Compressor
2	Control cabin	7	Double safety relief valve with changeover valve
3	Condenser	9	Filter drier
4	Evaporator	10	Expansion valve
5	Subcooler	11	Main switch and either variable frequency drive, star-delta starter or soft starter



P-PISTON-SERIES

High temperature with superb part load range

- Up to 230-248 deg F hot water with full capacity
- Refrigerant choices
 - R134a, R450A, R513A, R1234ze, R1233zd

Based on reciprocating piston compressors



Variable frequency drives as option

- Higher capacity
- Precise control
- Up to 4 compressors can be equipped with VFD (VFDx4)

Pos.	Part	Pos.	Part	
1	Control panel	7	Compressor	
2	Control cabin	8	Refrigerant pressure double relief valve with change valve	
3	Evaporator	10	Dryer-filter	
4	Condenser	11	Expansion valve	
6	Subcooler	12	Frequency converter	

ChilPtest P 60 - P 450 main parts



INDUSTRIAL HEAT PUMPS AND CHILLERS

Туре	P-series	S-series	RE -series
Model	P30, P60, P100, P150, P220, P300, P380, P450	S180, S280, S380, S490, S580 S600, S800, S1000, S1200, S1500, S2000	RE210, RE330, RE420
Compressor	Recip-Piston	Screw	Scroll
Refrigerant	R134a, R513A, R450A, R1234ze, R1233zd	R134a, R513A, R450A, R1234ze	R410A



Video: https://www.youtube.com/watch?v=PBhlKxL8FBY



- Compact and easy-to-maintenance design
- Electrical cabinets & comprehensive automation
- Factory acceptance test (FAT) including test run in test-bench for each delivery prior to shipment







Heat Pump Applications



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Advances in Technology & Refrigerants are Leading to Higher Capacity & Higher Temperature Heat Pump Applications





Heat Pump Applications

Cooling and Heating

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COOLING AND HEATING

Heat Pump Applications

CHC – Concept description



Traditional cooling process

- The low-grade heat from the cooling process is wasted
- Expected COP 3.5 5

CHC concept

- · Heat from cooling process is recovered to DHN with heat pump
- COPcombined 4 7
- Scale:
 - 68,000 BTUh to 10,000 BTUh (800 Tons) for large buildings as commercial centers, airports, universities and hospitals.





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COOLING AND HEATING

Simultaneous cooling and heating



- This will give the best COP value (COPh+COPc = COPtot)
- Buffer tanks will help balance the system running
- In ChillHeat automation you can give set point for both heating and cooling temperature

Heat Pump Applications



Heat Pump Applications

COOLING AND HEATING

CHC: Hospital, Finland



Heat source: Hospital water cooling network

- Cooling capacity: 3,070 MBh (256 Tons) ٠
- Heating capacity: 4,709 MBh ٠
 - Heat sink: District heating network
- Water temperatures(cooling/heating): 50 °F / 158 °F ٠
- Cop combined: 4.8
- ChillHeat pumps: •

GPM

- 1 pcs. P300 SU HC VFDx4 ٠
- 1 pcs. S600 ECO VFDx1

480 Kw Electrical Power

4,709 MBH, 349



3,074 MBH (256 Tons), 682





Heat Pump Applications

Cascade System Air Source to Water Source Cooling and heating and heat extraction from outdoor air

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CASCADE AIR SOURCE TO WATER SOURCE







Heat Pump Applications





Heat Pump Applications

Ground source heating and hybrid solutions

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GROUND SOURCE HEATING AND HYBRID SOLUTIONS

Heat Pump Applications

Hybrid solution





GROUND SOURCE HEATING AND HYBRID SOLUTIONS

Heat Pump Applications

Hybrid system:



Heat of schools, hospital, residential buildings

- Chiller plant
 - Cooling capacity 6,800 MBH (566 Tons)
- ChillHeat heat pump
 - Heat pump: 1 or 2 P300 SU or S Series
 - Heat source: Heat recovery geothermal heat and a cooling system Heating capacity: 2,500 -5,000 MBh
- Base Load Boilers
 - Heating capacity 1 or 2 2,500-5,000 MBh
 - For peak loads and reserve capacity



GROUND SOURCE HEATING AND HYBRID SOLUTIONS

Heat Pump Applications

Hybrid system





MAXIMUM 240 °F HEAT PUMP

Heat Pump Applications

230-240 °F heat pump technology



- New technology now available for ChillHeat P-series
 - Maximum temperature of heated water 230-240 °F
 - Future proof refrigerant GWP 1
 - Safety class A1
- Example connection for booster heat pump system utilizing DH return water for new or existing customers
 - Heat load 58,000 MBH (From 113 to 230 °F)
 - Electricity for HP 424 kW
 - COPh 4.0
 - 2 x ChillHeat P450 heat pumps



QUESTIONS???

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